Survival of Malleefowl *Leipoa ocellata* Chicks in the Absence of Ground-dwelling Predators

DAVID PRIDDEL & ROBERT WHEELER

National Parks and Wildlife Service (NSW), P.O. Box 1967, Hurstville, N.S.W. 2220

Received 20 October 1988, accepted 24 February 1989

Summary

Priddel, D. & Wheeler, R. (1989). Survival of Malleefowl *Leipoa ocellata* chicks in the absence of ground-dwelling predators. *Emu* **90**, 81-87.

Malleefowl eggs were collected from the wild and incubated artificially. Week-old chicks were released into four 1-ha enclosures of natural mallee vegetation. Water was placed into one enclosure, rabbits into another, seed into a third and a fourth was left unaltered. Of 20 chicks released into the non-seeded enclosures, all survived only 1-22 days (median = 4 days). Starvation was the underpinning cause of death, individuals losing body weight at a rate of up to 7% day^{-1}. Chicks without sufficient food were more susceptible to chilling, particularly after rain, and more vulnerable to raptors than those fed *ad libitum*. Of nine chicks released into the enclosure with supplementary food, only one died (as a result of chilling six days after release); all the rest survived beyond 30 days (the duration of the experiment). Subsequent transfer of surviving chicks from the enclosure with supplementary food to others containing only natural mallee vegetation resulted in their body weight decreasing up to 6.4% day^{-1}, sufficient to cause the death of one chick after just three days.

Introduction

Both the distribution and abundance of Malleefowl *Leipoa ocellata* have declined substantially since European occupation of the semi-arid regions of Australia (Griffiths 1954; Frith 1962a; Blakers *et al.* 1984). Undoubtedly, the major cause of the decline has been the removal of suitable habitat, brought about by the clearing of mallee lands for agriculture, largely for the cultivation of wheat. Only isolated remnants of mallee now remain where Malleefowl were once most abundant. Any large tracts of mallee still existing are marginal for both wheat and Malleefowl, and densities of Malleefowl in these areas were never as great as in those now cleared for agriculture (Frith 1962a).

Clearing of mallee lands is not the only threat to the survival of Malleefowl, for Malleefowl densities have declined substantially in areas of mallee which remain intact (Frith 1962a). This decline appears to be continuing. Although Frith (1959) found Foxes *Vulpes vulpes* unearthed and destroyed about 37% of eggs, he suggested that the predominant cause of the Malleefowl's decline in areas of remaining mallee was domestic stock. Stock compete directly with Malleefowl for herbaceous food plants and indirectly by grazing the shrubs on whose seeds the Malleefowl also feeds. Recent evidence, however, suggests Malleefowl populations are also declining in areas of mallee which are not grazed by domestic stock (Brickhill 1985). Such a decline must result from a reduced number of breeding pairs, a reduction in the fecundity of these pairs or reduced survival of their offspring. The possibility of lowered individual fecundity appears least likely as, on average, each pair of breeding Malleefowl successfully produces 8-11 chicks per year (Table 1). These chicks are fully fledged upon hatching; i.e. they are able to fly and are totally independent of their parents. Thus, although high rates of hatching success do occur in other gallinaceous species (Johnsgard 1973), few such species successfully produce as many fledglings as do Malleefowl. For Malleefowl populations to be in decline, the high fecundity of breeding individuals must be offset by low numbers of breeding pairs, or low survival of chicks or juveniles. Possible causes of reduced survival are numerous and include: congenital defects; disease; parasites; pollutants; drought; fire; predation by Foxes or Feral Cats *Felis catus*; or shortage of food due to competition from introduced herbivorous species, such as Rabbits *Oryctolagus cuniculus* and Goats *Capra hircus*.

Unfortunately, little is known about the population dynamics of Malleefowl. Few data are available from which to estimate age-specific survival rates, recruitment rates or rate of population increase. Indeed, almost nothing is known of the life history of young or non-breeding Malleefowl. The aim of this study was to measure the survival of Malleefowl chicks during the first month of life in the absence of Fox and Cat predation, and to experimentally assess the effects of food, water and competition on chick survival.

Methods

Between October and December 1986, 15 active Malleefowl nesting mounds in the vicinity of Yalgogrin, New South Wales (33°49′S, 146°46′E) were visited every 2-3 weeks. At each visit, the mounds were excavated and the eggs removed from the egg-

0158-4197/90/0281 + 6 $2.00

TABLE 1 Fecundity attributes of Malleefowl (calculated from other sources).

	Frith (1959)	Booth (1987a)	Brickhill (1987)
Clutch size: range	5-33	2-34	3-33
Clutch size: mean	18.0	13.8	15.6
Mean per cent hatching	49.5	79.2	51.3
Mean number hatching	8.9	10.9	8.0

chamber and weighed. Eggs were measured, numbered with pencil, then returned to the egg chamber and the mound reformed. On 7-8 January 1987 all mounds were excavated, and their eggs collected. The eggs were weighed, packed in goose down, placed in padded insulated boxes and transported to Yathong Nature Reserve (32°40'S, 145°30'E). Each egg was then carefully placed into an open-topped, cylindrical polystyrene container (113 x 86 mm dia.) and maintained in a refrigerated incubator held constant at 34°C.

The first hatching took place on 8 January and the last (29th) on 10 March. Each chick was weighed, fitted with three coloured leg-bands and released into an outdoor holding pen (approximately 20 m² x 2 m high) within 24 h of hatching. The pen was partly roofed and partly vegetated with cereal crops. The chicks had continuous access to water contained in a drinking trough, to seeds (millet, rape, linseed, canary, panicum) scattered about the earthern floor and to invertebrates attracted by incandescent light. Each chick was also offered mealworms at least twice daily.

Chicks in the holding pen were captured and weighed nightly. On the second night after hatching, each chick was fitted with a miniature radio transmitter (model SM1, AVM Instrument Co., Livermore, California, U.S.A.) powered by a silver-oxide battery (MS76). The transmitter package (5-6 g) was mounted on a backpack fastened to the bird with cotton straps under each wing. At the same time, the primary feathers of the right wing were cut at their bases to restrict the chick's flight.

From earlier trials we found that some Malleefowl chicks did not feed readily during the first four days after hatching and, as a consequence, lost up to 10 g (9.2%) (mean 4.5 g) of body weight. Most captive birds regained this weight within the following week. Therefore, each chick used in this experiment was held in the holding pen until its weight had stabilised and it would readily accept offered mealworms (3-15 days, mean 7.5 days). Chicks were then released into one of four adjacent 1-ha experimental enclosures of natural mallee vegetation on Yathong Nature Reserve. Water in a drinking trough was provided in one enclosure; 15 rabbits added to a second enclosure, also with water provided; supplementary feed in the form of seed ('budgie mix') dispersed throughout a third; and the fourth left unaltered as a control. Water was maintained in the troughs throughout the experiment, with levels checked daily. Prior to the release of chicks, 160 g of seed was placed into each of 25 open-topped dishes (128 mm dia.) spaced evenly throughout the seeded enclosure and a further 20 kg liberally dispersed. Thereafter, to ensure an ample and continual supply of seed, the dishes were replenished daily and an additional 10 kg dispersed throughout the enclosure each week.

The enclosures were built in 1985; consequently the vegetation had not been grazed by mammalian herbivores for two years prior to this experiment. It was last burnt in 1974. An electric fence around the perimeter of the enclosures excluded Foxes and Cats. The four enclosures contained similar species of perennial plants at similar densities. Dominant species were *Eucalyptus socialis*, *E. dumosa*, *Acacia rigens*, *A. whilhelmiana*, *A. brachybotrya*, *Melaleuca uncinata* and *Triodia irritans*. This vegetation differed from that at Yalgogrin where the eggs originated. The site at Yalgogrin (558 ha), dominated by *Eucalyptus viridis*, *E. polybractea*, *E. behriana*, *E. microcarpa* and *Melaleuca uncinata*, also differed from Yathong Nature Reserve in that the selective harvesting of mallee eucalypts and Broombush for the production of eucalyptus oil and fencing material, respectively, had created a mosaic patchwork of natural and regenerating harvested vegetation.

The site at Yalgogrin, surrounded by agricultural crop and pasture lands, contained the highest density of Malleefowl known in New South Wales. Malleefowl had been seen only infrequently on Yathong Nature Reserve, and the population size and distribution were unknown.

Twenty-nine chicks were released over 64 days. The enclosure into which each bird was released was selected randomly. Each chick was located daily after release by tracking the radio transmitter attached to its back. Periodically, each chick was also radio-tracked to its nocturnal roosting site and weighed. Chicks surviving longer than 12 days were also recaptured at their roost and the transmitter battery renewed. At this time, the cut primary feathers of the right wing were again trimmed and, if necessary, the leg bands replaced with larger ones. Dead chicks were collected for post-mortem examination, and any crop and gizzard contents removed.

Results

Only eight of the 29 chicks released into the four enclosures survived for 30 days (the duration of the experiment). They had been released into the enclosure with supplementary food (Table 2). From results of single-factor analyses of variance, there were no differences between enclosures (treatments) in regard to the age of chicks on release ($F_{3,24}$ = 0.137; $P > 0.05$), release weight ($F_{3,24}$ = 0.484; $P > 0.05$), hatch weight ($F_{3,24}$ = 0.484; $P > 0.05$) or initial egg weight ($F_{3,20}$ = 0.764; $P > 0.05$), but survival time was greater in the enclosure containing supplementary food ($F_{3,24}$ = 24.342; $P < 0.001$).

Seventeen of the 20 chicks released into the enclosures without supplementary food (i.e. water, rabbits and control) died within the first eight days; one survived for 15 days and another for 22 days (Table 2); one chick fractured its leg and was removed two days after release. The number of days survived was independent of age on release (r = -0.034; t_{17} = 0.15; $P > 0.05$). The chick (#117) that survived longest (22 days) had been released into the enclosure with water added. It eventually died as a result of a cloacal blockage arising from the accumulation of dried faecal material around the cloacal opening. Until the time of death, it was increasing in weight at the same rate as those in the seeded enclosure (Fig. 1). We do not know why this individual was able to survive where others could not nor the reason for its unusual cause of death. Of the nine chicks released into the seeded enclosure, only one

TABLE 2 Weight, age and survival of Malleefowl chicks released into 1-ha experimental enclosures.

Enclosure treatment	Chick number	Egg[1] weight (g)	Hatch weight (g)	Release weight (g)	Release date	Age on release (days)	Survival time (days)	Cause of death
Control	164	183	117	114	15/01/87	6	6	Starvation
	134	170	111	109	21/01/87	3	3	Predatory bird
	167	184	117	113	09/02/87	6	3	Chilling
	129	167	102	110	09/02/87	11	3	Chilling
	173	***	108	107	14/02/87	7	4	Starvation
	116	177	115	133	26/02/87	14	6	Chilling
	158	173	103	120	12/03/87	9	5	Starvation
	Mean	176	110	115		8	4	
Water	132	171	109	105	15/01/87	4	8	Predatory bird
	108	173	110	103	17/01/87	4	1	Predatory bird
	120	189	114	111	23/01/87	3	1	Predatory bird
	136	165	101	134	08/02/87	14	4	Chilling
	147	173	102	124	08/02/87	8	4	Chilling
	166	146	92	87	14/02/87	11	1	Unknown
	117	179	114	115	18/02/87	4	22	Cloacal blockage
	Mean	171	106	111		7	6	
Rabbits and water	169	***	105	106	15/01/87	7	5	Starvation
	119	174	113	111	19/01/87	3	3	Predatory Bird
	137	170	102	96	24/01/87	3	1	Predatory Bird
	140	159	101	113	08/02/87	7	—	Removed[2]
	125	167	108	125	10/02/87	15	4	Starvation
	115	156	97	94	14/02/87	9	15	Unknown[3]
	Mean	167	105	106		7	6	
Seed	128	173	113	107	15/01/87	6	>30	—
	110	161	107	97	23/01/87	6	>30	—
	118	172	82	85	17/02/87	7	>30	—
	107	181	117	118	18/02/87	6	>30	—
	172	***	117	110	26/02/87	4	6	Chilling
	174	***	117	132	26/02/87	10	>30	—
	109	170	99	115	12/03/87	10	>30	—
	123	176	112	114	19/03/87	12	>30	—
	143	167	103	112	20/03/87	10	>30	—
	Mean	171	107	110		8	>30	

1 Estimated egg weight at time of laying. Calculated by plotting egg weight throughout incubation and extrapolating weight at 62 days prior to hatching.
2 Withdrawn from the experiment two days after release because of fractured leg. Omitted from calculation of means.
3 Despite extensive searches, not seen after 15 days post-release; presumed dead.
*** Insufficient data from which to estimate initial egg weight.

(#172) died. It survived in the enclosure for six days but died within 24 h of being drenched by 57 mm of rain.

Prima facie causes of death were: predation by raptors (n = 6), starvation (n = 5), chilling after rain (n = 6), cloacal blockage (n = 1), and unknown (n = 2). All chicks, except one (#172), had little or no food in the crop or gizzard, indicating that starvation was a contributing factor in their death. Corpses were severely dehydrated due to high ambient temperatures, often in excess of 40°C, and therefore could not be used to measure accurately weight loss of individuals prior to death. However, two chicks were weighed shortly before death. Chick #169 weighed 106 g when released but only 83 g when moribund just four days

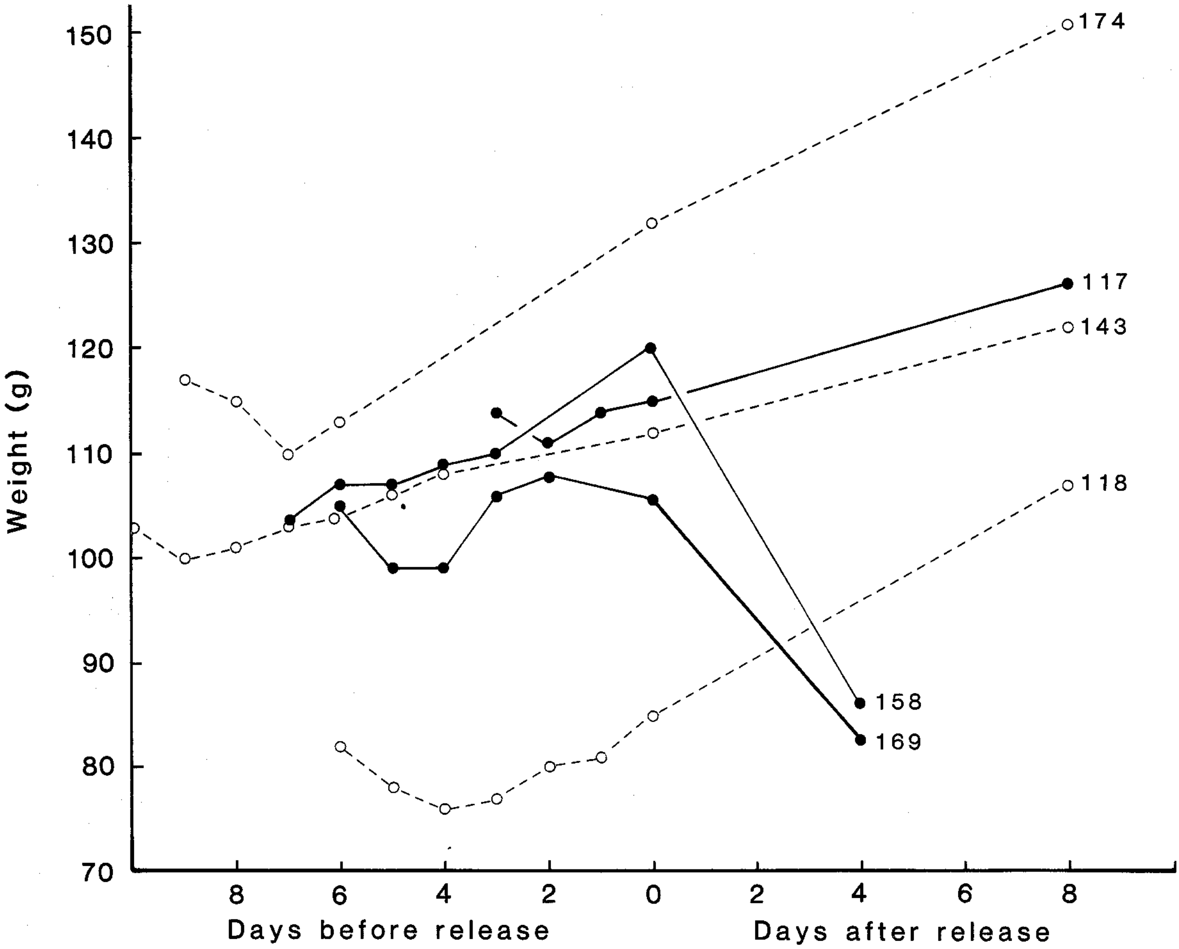

FIGURE 1 Weights of newly-hatched Malleefowl chicks prior to and immediately after release into seeded (open circles) and non-seeded (solid circles) enclosures. For clarity, data are not presented for all chicks; those selected (except #117) were typical of each treatment. Data from chick #117 was included because it was uniquely atypical.

later (Fig. 1): a decrease in body weight of 22% in just four days. It was removed from the experiment at this time but did not recover. Chick #158, unable to move and barely alive after four days in the control enclosure, weighed just 86 g compared to 120 g when released. This represents a 28% loss in body weight in four days (Fig. 1), whilst over the same period those chicks in the seeded enclosure gained an average of 7.2 g or 6.8% in body weight. Chick #158, close to death, was removed from the experiment and carefully nursed back to health. Within 15 days it had regained its pre-experimental weight. Prior to any intervention, chicks #158 and #169 showed the following symptoms of ill health: heavy panting through open mouth; prostrate body with wings spread; head swaying or drooping; and feathers erect. All chicks exhibiting such symptoms (#125, 147, 164, 167 and 173) died within 24 h, suggesting that without intervention, the deaths of chicks #158 and #169 were imminent.

Six Malleefowl chicks were taken by raptors; the cause of their death being determined from the examination of remains found outside the enclosures. Feathers, and occasionally the transmitter, entangled in the bark of a branch overlooking the remains often confirmed the initial findings. A Spotted Harrier *Circus assimilis* was the only species observed hunting Malleefowl chicks. None of the chicks taken by raptors were from the seeded enclosure, despite this enclosure containing the greatest density of chicks. Incidental but frequent observations suggested that the higher rate of predation in non-seeded enclosures was a consequence of the chicks' behaviour making them more conspicuous and therefore more vulnerable to raptors.

Chicks in these enclosures were in open areas more often than those in the seeded enclosure, the latter rarely being seen away from the protection of vegetative cover.

No chick made any attempt to shelter during rain and all soon became saturated despite their feather covering. Six chicks died within 24 h after heavy rain; only one died in the seeded enclosure compared to five in the non-seeded enclosures. Chicks experiencing food shortage in the non-seeded enclosures were more susceptible to chilling following rain than those in the seeded enclosure, presumably because their poor body condition and consequent low energy reserves prevented them from sustaining the elevated metabolic rate necessary to maintain body temperature under such conditions.

Sixty-one days separated the first and last hatching. The time span of releases into the enclosures was similar (64 days), as each chick was released when approximately one week old (Table 2). The interval between successive releases into the same unseeded enclosure averaged 7.0 days; longer than the mean period (5.3 days) of survival in the non-seeded enclosures (Table 2). Thus, although up to seven chicks were released into the same non-seeded enclosure, at any given time each enclosure usually contained one individual and never more than two.

Following the death of all chicks released into the non-seeded enclosures (March 1987), further experiments were conducted on the chicks surviving in the seeded enclosure. On 5 June 1987, four chicks were taken from the seeded enclosure; two were transferred into each of two similar, but previously unused, non-seeded enclosures. Two years earlier, the leaf litter in one of these enclosures was experimentally increased 10-fold in an attempt to increase the abundance of litter invertebrates, an important component of adult Malleefowl diet (Booth 1986). All chicks were weighed on release, then recaptured and reweighed three days later. All had lost considerable weight (Table 3), and based on previous results we concluded that if left without supplementary food their death was imminent, so all were returned to the seeded enclosure. Three chicks regained their pre-experimental weight within just two days but the fourth did not recover. There was no difference in total or percent weight loss of birds in the enclosure with increased leaf litter compared with the chicks in the non-manipulated enclosure.

The experiment was repeated in July. This time the birds were weighed just one day after release. All had lost 5-6% of body weight (Table 4), again suggesting death to be imminent, so all were returned to the seeded enclosure. Meanwhile a chick handled in the same manner but re-released into a seeded enclosure lost only 6 g (1.5%) in weight.

Discussion

This study has demonstrated that, given sufficient food and protection from ground-dwelling predators, Malleefowl

TABLE 3 Weight changes of Malleefowl chicks during three days immediately following transfer from seeded to non-seeded enclosures (5-8 June 1987).

Enclosure	Chick number	Age on transfer (days)	Weight on transfer (g)	Weight on recapture (g)	Weight change (%)	Weight change (g day^{-1})
Non-seeded + litter	109	95	263	229	-12.9	-11.3
Non-seeded + litter	107	113	370	350	- 5.4	- 6.7
Non-seeded	143[a]	87	265	239	- 9.8	-10.4
Non-seeded	174	109	445	415	- 6.7	-10.0

a Removed from experiment 2.5 days after transfer due to ill-health; it died 2 hours later.

TABLE 4 Weight changes of Malleefowl chicks during one day immediately following transfer from seeded to non-seeded enclosures 23 July 1987.

Enclosure	Chick number	Age on transfer (days)	Weight on transfer (g)	Weight on recapture (g)	Weight change (%)	Weight change (g day^{-1})
Non-seeded + water	128	195	560	527	-5.9	-33
Non-seeded	109	143	375	351	-6.4	-24
Non-seeded	174	157	576	548	-4.9	-28
Seeded	158	142	389	383	-1.5	- 6

chicks emerging from mounds have a good chance of surviving the first month of life. This finding lessens, although it does not completely rule out, the likelihood of some congenital defect, disease, parasite or environmental pollutant as the cause of the decline in population numbers.

Although some captive Malleefowl were observed to drink, this study has demonstrated that, providing there is sufficient food, Malleefowl chicks can survive and grow in the absence of free-standing water. No water was provided in the seeded enclosure. Malleefowl often inhabit areas where no permanent surface water is available and it has long been assumed that they do not need to drink (e.g. Frith 1962b). Water turnover in Malleefowl is much less than in other bird species (Booth 1987b), partially because they make efficient use of metabolic water. Nonetheless, when available, Malleefowl sip droplets of dew or rain collected at the leaf tips; they also get moisture from the insects and succulent plants and roots they consume.

This study has also demonstrated that, between January and March 1987, there was insufficient food within a 1-ha plot of mallee vegetation to sustain Malleefowl chicks weighing just 100-200 g. This is despite vegetation in the plot having been protected from all mammalian grazers for the previous two years. There are two alternative explanations: either (a) the quantity or (b) the quality of the habitat within the enclosures was inadequate. The first alternative implies that Malleefowl chicks require more than 1 ha in which to survive and although suitable food existed within the enclosure, it was rapidly eaten out. Thus, chicks given the opportunity to wander further would have found sufficient food. The second alternative implies that the mallee community within the enclosures was not suitable habitat, containing little or no food suitable for Malleefowl chicks. Thus, if chicks were released outside the enclosure, they would have found food only if they found suitable alternative habitat.

Of the various mallee communities on Yathong, that within the enclosures was subjectively regarded as the most suitable for Malleefowl. Relative to other mallee areas, it contained a high density of shrubs, particularly *Acacia*. *Acacia* seeds are believed to be a major component of the diet of adult Malleefowl over summer (Frith 1962a; Booth 1986). The findings of this study question the importance of *Acacia* seeds in the diet of malleefowl chicks, particularly since the seeds of many *Acacia* species have an ant-attracting appendage ('elaiosome', Sernander 1906) and are sought after and transported underground by ants soon after they are shed (O'Dowd & Gill 1986; R. Bradstock, pers. comm.). By February, few *Acacia* seeds remained above ground.

Nothing is known of the food or energy requirements of Malleefowl chicks, yet if those in the non-seeded enclosures lost weight at a rate of up to 7% day^{-1}, it follows that a 110 g (mean release weight) chick needs to consume in excess of 7.7 g of food daily. Further, given that the minimum water influx needed for Malleefowl chicks to maintain body weight is approximately 70 ml kg^{-1} day^{-1} (Booth 1987b), a 110 g chick must take in at least 7.7 g of water daily. Assuming that (i) the water content of seed is about 10% and (ii) 0.54 g of metabolic water is produced from each gram of seed consumed (Schmit-Nielsen 1985), a chick obtains 0.64 g of water from each gram of seed eaten. If the diet were to consist solely of seeds, the minimum quantity of seed required by Malleefowl chicks to maintain body weight would therefore be 7.7/0.64 = 12.0 g daily.

Given the possibility that the quality of the habitat within the enclosures is unsuitable, we can ask whether it has always has been so, or whether it is only temporary? The preceding months may have been unfavourable for the germination, growth or seeding of food plants, or for the reproduction or emergence of litter invertebrates. It may be that Malleefowl chicks can only survive in the relatively infrequent years when unusually good rainfall produces an abundance of food and in normal, poorer years usually no chicks survive. Alternatively, the age of the mallee community (i.e. time since last fire) may be the crucial determinant of habitat suitability for Malleefowl.

If we are to manage areas of mallee to conserve Malleefowl, it is not sufficient just to remove exotic predators. Before attempts can be made to halt or reverse the decline in Malleefowl numbers, we must know how the age and species composition of mallee communities affects the availability of food for Malleefowl chicks and adults.

Acknowledgements

We are grateful to Cyril Kalms, Lindsay Darrington, Roy Woods and Alan Jones for granting us access to their properties. John Brickhill informed us as to the whereabouts of Malleefowl nests. Numerous volunteers, predominately university undergraduates, kindly assisted in locating nest mounds, collecting eggs and constructing the enclosures, often under extremely arduous conditions. John Warren and Harry Warren provided technical expertise and assistance in the design and construction of the enclosures. Geoff Ross assisted in locating nest mounds, construction of the enclosures, supervision of volunteers, and initial incubation trials. Bev Warren kept a watchful eye on the incubators and assisted with the incubation in our absence. The manuscript was improved by comments from Sue Briggs, Richard Kingsford and David Booth.

References

Blakers, M., Davies, S.J.J.F., & Reilly, P.N. (1984). *The Atlas of Australian Birds.* RAOU and Melbourne Univ. Press, Melbourne.

Booth, D.T. (1986). Crop and gizzard contents of two mallee fowl. *Emu* **86**, 51-53.

Booth, D.T. (1987a). Home range and hatching success of malleefowl, *Leipoa ocellata* Gould (Megapodiidae), in Murray mallee near Renmark, S.A. *Aust. Wildl. Res.* **14**, 95-104.

Booth D.T. (1987b). Water flux in malleefowl *Leipoa ocellata* Gould (Megapodiidae). *Aust. Wildl. Res.* **35**, 147-159.

Brickhill, J. (1985). An aerial survey of malleefowl nests at Round Hill Nature Reserve. *Aust. Wildl. Res.* **12**, 257-261.

Brickhill, J. (1987). Breeding success of malleefowl *Leipoa ocellata* in central New South Wales. *Emu* **87**, 42-45.

Frith, H.J. (1959). Breeding of the mallee-fowl, *Leipoa ocellata* Gould (Megapodiidae). *CSIRO Wildl. Res.* **4**, 31-60.

Frith, H.J. (1962a). Conservation of the mallee-fowl, *Leipoa ocellata* Gould (Megapodiidae). *CSIRO Wildl. Res.* **7**, 33-49.

Frith, H.J. (1962b). *The Mallee-Fowl: The Bird That Builds An Incubator.* Angus & Robertson, Sydney.

Griffiths, F.J. (1954). Survey of the lowan or mallee-fowl in New South Wales. *Emu* **54**, 186-189.

Johnsgard, P.A. (1973). *Grouse and Quails of North America.* Univ. of Nebraska, Lincoln.

O'Dowd, D.J. & Gill, A.M. (1986). Seed dispersal syndromes in Australian *Acacia.* In: *Seed Dispersal* (ed. D.R. Murray) pp. 87-122. Academic Press, Sydney.

Schmit-Nielsen, K. (1985). *Animal Physiology: Adaption and Environment.* Cambridge Univ. Press, Cambridge.

Sernander, R. (1906). Entwurf einer monographic der europaischen myrmekochoren. *Kunglica Svenska Vetenskapakademien Handlingar* **41**, 1-410.